

Application of Skid Resistance Measurements

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SKID RESISTANCE MEASUREMENTS

It is perhaps unfortunate that we have come to talk about skid resistance of pavements, rather than their frictional characteristics or their coefficient of friction. In applying skid resistance measurements we aren't really so much concerned with skidding as with the prevention of skidding. Once a car skids, it is already in trouble and what we try to do through pavement surface design and maintenance is to keep the skidding car as much out of trouble as is humanly possible.

Resistance Between Tires and Pavement

Skid resistance measurements are measurements of the resistance developed between tire and pavement when the locked tire slides along the pavement. What goes on at the interface between the tire and pavement is determined by the characteristics of the tire and the pavement (and additionally by operational and environmental conditions, such as speed, waterfilm, temperature, etc.). Using the same tire in all measurements and holding the test conditions constant, as for instance ASTM Method E 274 prescribes, the frictional characteristics of various pavements can be defined—at least on a comparative basis.

Slipperiness Measured Quantatively

It is therefore possible to attach a number to the degree of slipperiness. This is fine and useful, but it immediately raises the question of what is slippery and what is not. This is not an easy question to answer. The first impulse is to look to accident figures for an answer.

ACCIDENTS RELATED TO SKID RESISTANCE

Skidding occurs whether a pavement is dry or wet. Skidding can be the cause of an accident or the consequence of one. Accident data are as yet not sufficiently refined to draw very precise conclusions from them. Obviously the risk of skidding is the greater the slipperier the pavement is. Referring the number of accidents reported that involve skidding to the total number of accidents on selected road sections and relating them to measured skid resistance we find two things:

1. There are still skidding accidents at the highest observed skid resistance,
2. The curve may have a slight knee at some value of skid resistance; below it the increase of skidding accident frequency becomes somewhat steeper than it is above it.

Too Slippery Distinguished from Passably Slippery

Unfortunately the knee is not very pronounced, it shifts with the characteristics of the road system and other factors. The only valid general statement which can be made about it is that it occurs in the skid resistance range into which wet pavements fall and dry ones do not. People have, of course, tried to use it and have concluded that a coefficient of friction of 0.4, or a Skid No. of 40, best describes the dividing line between too slippery and passably slippery.

Measurements at High Accident Spots

Statistically, accidents are a rare occurrence and they are therefore not the best guide for generalized deductions. They can, however, be an extremely useful tool for identifying trouble spots. If there are repeated wet skidding accidents in the same location skid resistance measurements can determine whether or not slipperiness is a major contributing factor.

Hydroplaning

A word of caution—tests are normally run with the pavement initially dry, however, a controlled amount of water is applied during the skid resistance measurement. This is being done because the prime objective is to ascertain the frictional characteristics of the pavement. But if during a rain an excessive amount of water accumulates the skid resistance measurements will not reflect this, but the accident statistics will. Tires hydroplane. When they do water completely separates tire and pavement and pavement characteristics no longer play any part.

Good Drainage to Minimize Hydroplaning

The onset of hydroplaning is strongly speed dependent, but it also changes with the depth of the tire tread pattern and the water escape channels in the pavement. For this reason pavement grooving can be very helpful where the water depth on the pavement tends to be excessive. Grooving should, however, be used as a remedy only. Providing for adequate runoff in the first place is the best method of preventing hydroplaning.

Resurfacing

Pavements can and should be resurfaced if it has been established beyond doubt that skid resistance is the real source of trouble in a particular location. Before dealing with the how and what, let us return to our original concern, that of a cutoff between acceptable and nonacceptable skid resistance.

ACCEPTABLE AND NONACCEPTABLE SKID RESISTANCE

All of us drive on snow and ice. When we do we adjust our driving to the conditions. We may still go 50 mph or more on open stretches, but we negotiate curves gingerly and we start to slow down early when we see a problem situation ahead. Knowingly or unknowingly that is what every driver does even when the roads are merely wet. The fact is that drivers drive very much the same way whether the pavement is wet or dry. True, this may sometimes bring them to grief when it is wet, either because an unexpected emergency arises or because the pavement turned out to be more slippery than usual or than it looked.

In any case, there can be little argument that the skid resistance of all pavements, when wet, should be such that it can accommodate normal traffic maneuvers. This means, that normal, though not just average, accelerations should be possible without wheel spin, that wheels shouldn't break away when rounding a curve or cornering in the normal course of driving.

Manual to Prescribe Skid Resistance Values

The skid resistance values which permit this, form the basis of the requirements for minimum skid resistance values, which will be contained in the forthcoming Volume 12 of the Highway Program Manual of FHWA. The prescribed values do not allow for the higher demands which a curve might impose which drivers frequently take too fast because the approach view of the curve is deceptive. Nor do they make allowance for the higher than normal decelerations which frequently occur at a signal light which has a too short yellow cycle. They merely put a bottom under the structure. They do not say, that at no time should skid resistance be any less than the stated values at any location.

Skid No. of 37 Permissible Minimum

The manual gives a Skid No. of 37 as the basic figure. Since the manual refers to ASTM Method E 274 it means that this is the value measured at a tester speed of 40 mph, provided, however, that

the average traffic speed on the road in question is also 40 mph. When the traffic speed is higher the required Skid No's. (measured at 40 mph) are higher.

This is not so because the normal driver demands become more severe at higher speeds. On the contrary, drivers use for instance more modest decelerations at the higher speeds than they do at lower ones. If, however, skid resistance is measured at a speed (40 mph) lower than the traffic speed it is necessary to make allowance for the fact that on any pavement the available skid resistance decreases with speed when the pavement is wet. This decrease is not the same for all pavements; the standard is based on an average value. Thus, though a Skid No. of 37 is considered the permissible minimum at a traffic speed 40 mph, it is 46 for a traffic speed of 70 mph.

Disagreement Over Skid No. Values

Many do not agree with the numbers, either because they consider the numbers too low for safety reasons or because they think the numbers too high since they make too much of a highway system sub-standard. There can be little argument that safety would be better served if skid resistance were maintained at higher values than the prescribed ones.

AGGREGATE POLISHING

This is, in many instances, however, easier said than done. When a surface course is first laid down it almost always will be well above the minimum requirements. Time causes the difficulties. There are aggregates which polish severely under exposure to traffic. If only such aggregates are available within reasonable distance of the point of usage, costs can go up rather rapidly, if frequent resurfacing is needed to remain within the standard or if aggregates must be obtained from far-away sources if resurfacing is to be held to a minimum.

Factors Affecting Polishing

The polishing of aggregates is a complex process. It is obviously a function of the amount of traffic which a pavement carries. There is good reason to believe that the polishing process is greatly influenced and accelerated by the fine dust which is present on all road surfaces. Whether polishing could be retarded by removal of loose polishing agents is not clear yet. It appears that the offending particles are those which embed themselves in the tire surface. Whether these could be removed thoroughly enough to make a significant difference remains to be found out.

Skid No. Changes with Polishing

Although every pavement attains eventually an equilibrium Skid No., this value is neither reached in a continuous fashion, nor does it, once reached, remain at rock bottom. During the winter, freezing and thawing, salt, chains, studs, etc. work on the pavement and either reverse the polishing process or at least slow it down. Rain, surprisingly, also reverses the trend, though by a much smaller amount, perhaps because the polishing agents are flushed away. This statement, which refers to prolonged rain, does not contradict the common experience that a pavement is most slippery at the beginning of a rain.

Binder and Filler Play Minor Role in Flexible Pavements

Binder and filler play little, if any part, in the skid resistance of used, flexible pavements. In modern surface courses bleeding very rarely occurs. If it does, it can of course be fatal. But normally, what comes in contact with tires are the exposed, worn and polished tips or tops of the aggregate particles.

Aggregate Types—Lab Testing—Field Performance

Experience is, of course, an excellent guide as to which aggregates are more or less susceptible to polishing than others. Porous sandstones are for instance, superior to limestones containing no impurities. Our knowledge in this area is still less than what it might and ought to be. The main difficulty is that laboratory polishing procedures are still difficult to relate to field performance. Not the least of the obstacles is the already mentioned effect of environmental factors on skid resistance in the field. These factors must be quantitatively assessable before skid resistance surveys, which the National Highway Safety Program requires, can produce much more than relative ratings of aggregates. For this reason it is advisable in the East to make surveys in the fall of the year, because then skid resistance is fairly stable and at its lowest.

Aggregate Gradation and Surface Drainage

Once an aggregate has been selected for a surface course, the question still remains as to the best gradation. Gradation operates primarily through the size of the water-escape channels which are formed between aggregate particles. The higher the speed of the traffic, which the surface will carry, the larger the aggregate size should be. The channels control the amount of actual contact which the tire can make. At high speed the tire, long before hydroplaning occurs, is kept out of contact with the road surface at its forepart by the water wedge that forms at the entrance to the contact patch. The

length of the wedge increases with speed. The more readily the water can escape from the contact area the smaller the wedge will be and the slower it will grow.

Porous and Sharp Breaking Aggregate

Unfortunately even a skidding tire cannot wipe away all the water. Therefore aggregates which present a rough textured surface to tire will at least make locally direct contact with it. Consequently aggregates which are porous or which tend to form new rough surfaces as they wear and crumble are superior in terms of skid resistance.

Binder Important in Portland Cement Concrete Pavements

It may sound as if I have talked only about flexible pavements or asphaltic overlays. This is true, but the same basic principles apply to cement concrete pavements, with one exception—the sand in the mortar can be quite beneficial because the rigid matrix enables the sand particles to come in contact with the tire where this would not be the case with flexible pavements.

REJUVENATION OF PAVEMENTS

Unfortunately we do not yet have any widely applicable rejuvenation treatments. Flame treatment is useful in removing excess asphalt at the surface, acid treatment can roughen the surface of certain aggregate particles, but the effect is often not very lasting, cement concrete can be ground with an array of discs to produce a new surface with a finish resembling that of a broomed green surface. Though none of these methods has proven universally practical and economical they should not be overlooked for treating trouble spots.

CLOSURE

I hope to have shown, in a very brief overview, how skid resistance measurements can be applied to the task of providing safer pavement surfaces. Until we know much better what factors control skid resistance the measurements are indispensable in building up a stock of experience with local construction methods and materials, for meeting standards, and for scheduling resurfacing operations.